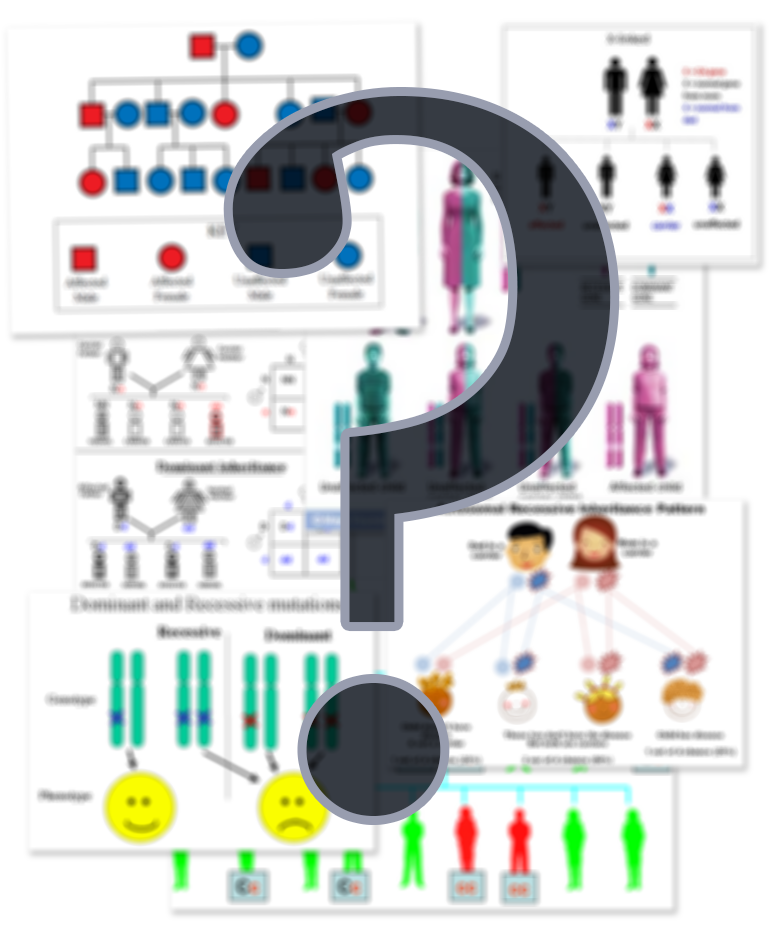
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**What are dominant and recessive?**

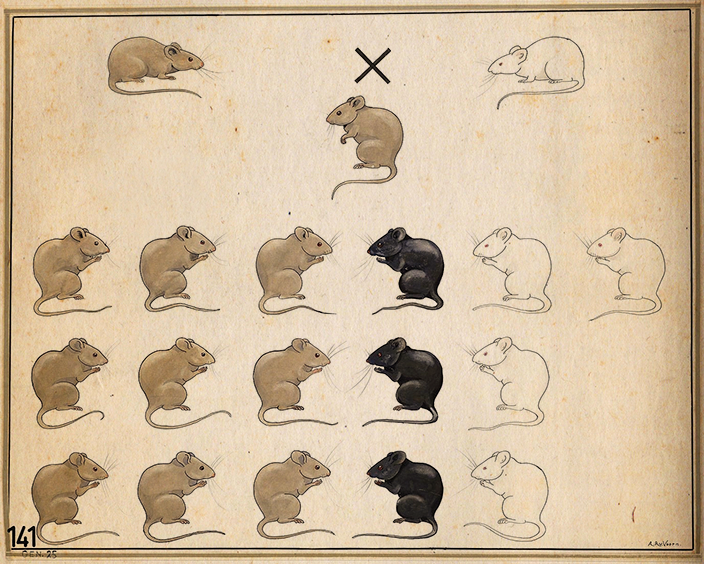
Source: <http://learn.genetics.utah.edu/content/inheritance/patterns/>

The terms dominant and recessive describe the inheritance patterns of certain traits. That is, they describe how likely it is for a certain phenotype to pass from parent offspring.

Sexually reproducing species, including people and other animals, have two copies of each gene. The two copies, called alleles, can be slightly different from each other. The differences can cause variations in the protein that’s produced, or they can change protein expression: when, where, and how much protein is made. Proteins affect traits, so variations in protein activity or expression can produce different phenotypes.

A dominant allele produces a dominant phenotype in individuals who have one copy of the allele, which can come from just one parent. For a recessive allele to produce a recessive phenotype, the individual must have two copies, one from each parent. An individual with one dominant and one recessive allele for a gene will have the dominant phenotype. They are generally considered “carriers” of the recessive allele: the recessive allele is there, but the recessive phenotype is not.

### The terms are confusing and often misleading

Dominant and recessive inheritance are useful concepts when it comes to predicting the probability of an individual inheriting certain phenotypes, especially genetic disorders. But the terms can be confusing when it comes to understanding how a gene specifies a trait. This confusion comes about in part because people observed dominant and recessive inheritance patterns before anyone knew anything about DNA and genes, or how genes code for proteins that specify traits.

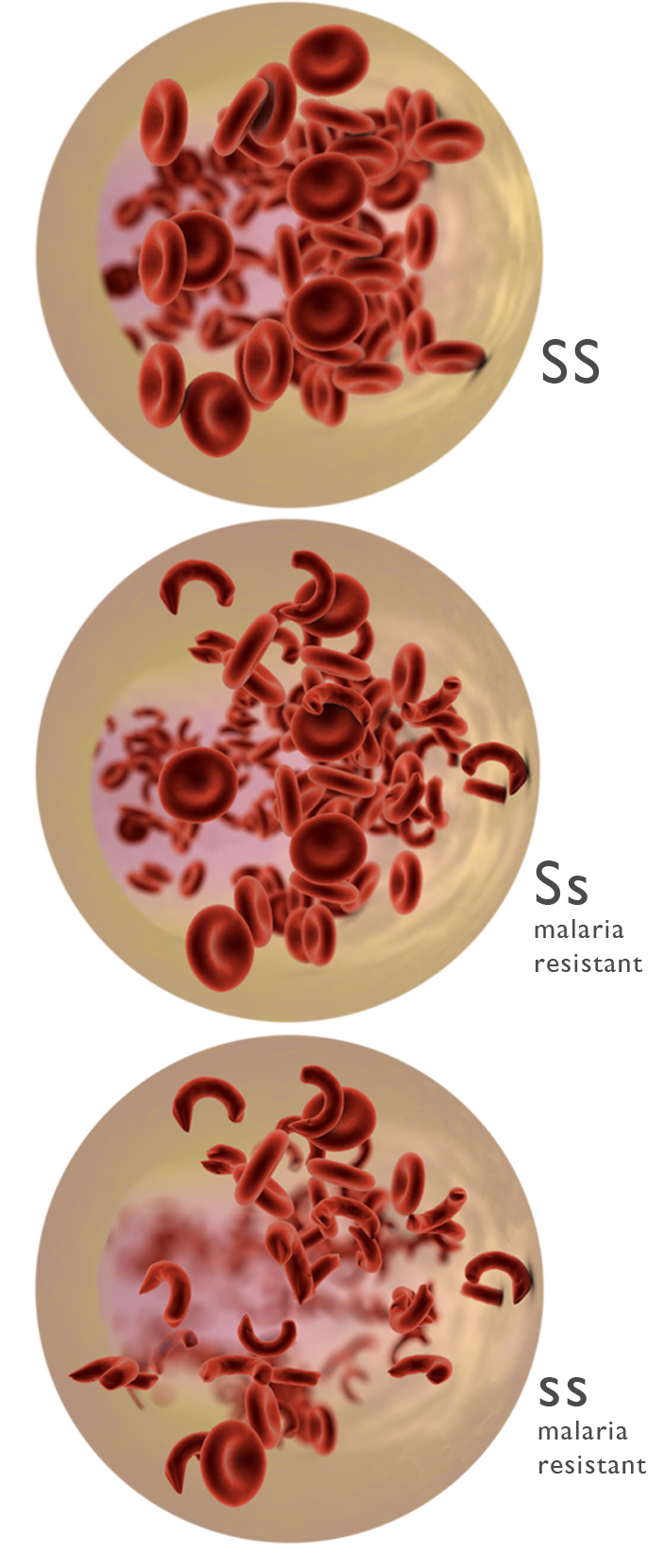
The critical point to understand is that there is no universal mechanism by which dominant and recessive alleles act. Dominant alleles do not physically “dominate” or “repress” recessive alleles. Whether an allele is dominant or recessive depends on the particulars of the proteins they code for.

The terms can also be subjective, which adds to the confusion. The same allele can be considered dominant or recessive, depending on how you look at it. The sickle-cell allele, described below, is a great example.

If you do a simple internet search, and you’ll find pages and pages of charts, images, and text explaining dominant and recessive inheritance patterns. However, these patterns apply to few traits.

### THE SICKLE CELL ALLELE

### Inheritance patterns

Sickle-cell disease is an inherited condition that causes pain and damage to organs and muscles. Instead of having flattened, round red blood cells, people with the disease have stiff, sickle-shaped cells. The long, pointy blood cells get caught in capillaries, where they block blood flow. Muscle and organ cells don’t get enough oxygen and nutrients, and they begin to die.

The disease has a recessive pattern of inheritance: only individuals with two copies of the sickle-cell allele have the disease. People with just one copy are healthy.

In addition to causing disease, the sickle-cell allele makes people who carry it resistant to malaria, a serious illness carried by mosquitos. Malaria resistance has a dominant inheritance pattern: just one copy of the sickle cell allele is enough to protect against infection. This is the very same allele that, in a recessive inheritance pattern, causes sickle-cell disease!

Now let’s look again at the shape of the blood cells. People with two copies of the sickle-cell allele have many sickled red blood cells. People with two copies of the “normal” allele have disc-shaped red blood cells. People with one sickle-cell allele and one normal allele have a small number of sickled cells, and their cells sickle more easily under certain conditions. So we could say that red blood cell shape has a co-dominant inheritance pattern. That is, individuals with one copy of each allele have an in-between phenotype.

So is the sickle cell allele dominant, recessive, or co-dominant? It depends on how you look at it.

### Protein function

If we look at the proteins the two alleles code for, the picture becomes a little more clear. The affected protein is hemoglobin, the oxygen-carrying molecule that fills red blood cells. The sickle-cell allele codes for a slightly modified version of the hemoglobin protein. The modified hemoglobin protein still carries oxygen, but under low-oxygen conditions the proteins stick together.

When a person has two sickle cell alleles, all of their hemoglobin is the sticky form, and the proteins form very long, stiff fibers that distort red blood cells. When someone has one sickle-cell allele and one normal allele, only some of the hemoglobin is sticky. Non-sticky hemoglobin is made from the normal allele, and sticky hemoglobin is made from the sickle-cell allele (every cell has a copy of both alleles). The sticking-together effect is diluted, and in most cells, the proteins don’t form fibers.

The protist that causes malaria grows and reproduces in red blood cells. Just exactly how the sickle-cell allele leads to malaria resistance is complex and not completely understood. However, it appears that the parasite reproduces more slowly in blood cells that have some modified hemoglobin. And infected cells, because they easily become misshapen, are more quickly removed from circulation and destroyed.